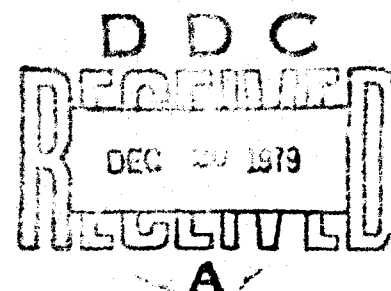


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RESEARCH MEMORANDUM 62-5

Prediction for
Radio Code Performance--
Recent Research and
Need for New ARC Test

SEPTEMBER 1962



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New Classification Techniques c-00

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memo

Research Memorandum 62-5

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PREDICTION OF RADIO CODE PERFORMANCE--
RECENT RESEARCH AND NEED FOR NEW ARC TEST

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Sep 1962

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PREDICTION OF RADIO CODE PERFORMANCE--RECENT RESEARCH
AND NEED FOR NEW ARC TEST

BACKGROUND

Since the introduction of the operational Army Classification Battery in 1949, continuous research effort has been directed toward maintenance and improvement of the tests and aptitude area composites. The primary objective of the research, now the mission of the NEW CLASSIFICATION TECHNIQUES Task, is to insure that instruments and procedures for classification meet changing Army job and manpower requirements.

Of the original ten ACB tests introduced in 1949, only one test, the Army Radio Code Aptitude Test (ARC-1), has not been the subject of a project for revision^{1/}. Two questions have delayed action with respect to revision of the ARC: In view of reduced input requirements, should the ARC continue to be a part of the ACB, or should it be made a special-purpose test for administration only to selected personnel such as volunteers for radio code jobs? Should the current loud-speaker presentation of the test content be continued?

PURPOSE OF THE RESEARCH MEMORANDUM

The need for continued utilization of the ARC--and for its revision--can be partly reflected by current and--to the extent possible--future Army needs for Morse code operators. One major purpose of the present Research Memorandum is to present general findings of a survey made by personnel of the NEW CLASSIFICATION TECHNIQUES Task to determine those needs. In addition, a review of recent research endeavors in the area of radio code operator selection was made for suggestions of possible value in improving prediction of radio code performance.

^{1/}Earlier, under the program to provide "common core" instruments for all Armed Services, the operational Verbal test (VE) was designed to replace the earlier Reading and Vocabulary Test (RV), and Forms 3 and 4 of the Arithmetic Reasoning Test were constructed to replace the original Forms 1 and 2. The Electronics Information Test (ELI) was constructed to replace the older Electrical Information Test and the Radio Information Test. The three new measures were introduced into the ACB in July 1957. Revision of the remaining ACB tests--except ARC--has been undertaken in order to provide more effective bases for classification to most Army jobs. In addition, two new tests, the Classification Inventory (CI) and the General Information Test (GIT), were added in October 1958 as the culmination of research on prediction of ability for combat jobs begun during the Korean War.

SURVEY OF CURRENT AND FUTURE RADIO CODE OPERATOR REQUIREMENTS

In 1953, input requirements for all radio code school and training courses was 4 percent. Requirements decreased from 1953 to 1961. However, a substantial increase in input for all courses teaching Morse code is reflected in 1962 quotas. For the MOS having the largest training requirement (MOS 053--Radio Teletype Operator), enlistee input for 1961, 1962, and 1963 was 3,200, 4,500 and 5,650, respectively. While projected requirements for all MOS training courses in Morse code had not been completed for 1963 at the time the present survey was made, evidence from data on hand indicated that the 1963 input will at least remain about the same as that for 1962. A list of specific quotas for training input to all such courses cannot be presented because of security restrictions on certain jobs. Table 1 presents a list of all enlisted MOS requiring code skill, approximate hours of code instruction for each MOS, and the proportion of working time code is used on the job.

Although use of Morse code has decreased, the need for men proficient in the skill still exists. Morse code, as a method of communication, is known to be secondary to other methods in amount of use. About half the MOS requiring training in Morse code demand little if any on-the-job utilization of the skill (Table 1). In special cases, however, Morse code communication has been found to be less affected by static and channel noise than other methods of communication more commonly used. Proficiency in the skill remains critical to performance in these jobs, since incumbents may be called upon to supply communication when the usually more efficient methods break down. Moreover, so far as could be ascertained, replacement of the manual method by special devices is not projected for the near future. If the manual method is replaced by an automatic device, initial replacement would most likely be at the USASA level. At present, only 30 to 40 percent of the total radio code input is accounted for by the USASA.

Development of an improved radio code selector has been under consideration by the Task for some time. Task personnel have therefore surveyed recent research in the area in order to have at hand an up-to-date evaluation of developments which might contribute to more effective prediction of performance and the identification of factors critical to performance. The following section presents some of the research efforts considered most germane to selection of radio code operators in the Army today.

RECENT RESEARCH ON RADIO CODE OPERATION

METHOD OF TEST PRESENTATION

Aural presentation of the Army Radio Code Aptitude Test on a group basis requires the use of loudspeaker equipment. Creager and Dettler (1954) tested the relationship between seat location and performance on the Signal Corps Code Aptitude Test (SCCAT) and the Army Radio Code

Table 1
MOS IN WHICH RADIO CODE CAPABILITY IS UTILIZED OR REQUIRED

MOS	School Providing Training	Hrs. Code ^a Taught	Time Used on Job
050 - Low Speed Radic Operator	Adv. Indiv. Tng.	173	Full Time
051 - Intermediate Speed Radio Operator	Adv. Indiv. Tng.	245	Full Time
053 - Radio Teletype Oper.	Service School	224	Little. Proficiency must be maintained
054 - Special Identification Techniques Supervisor	USASA School	0	Little. Proficiency must be maintained
055 - Communications Monitor	USASA School	25 ^b	Frequent
056 - Direction Finding Operator	USASA School	73 ^b	Frequent
057 - Transmission Ident. Operator	USASA School	22 ^b	Little. Proficiency must be maintained
058 - Morse Interceptor	USASA School	575	Frequent
059 - Teletype Interceptor	USASA School	29 ^b	Little. Proficiency must be maintained

^aExcept for 053 MOS, hours code taught is an approximation which includes refresher practice, practical exercise, and field training as well as class work.

^bHours code taught in addition to 288 hrs. received while in phase I and II training in 058 MOS (all USASA courses start in 058 MOS).

Attitude Test using loud-speaker administration. The main purpose of the study was to determine if location effects did exist and, if so, to determine if such effects were serious from the standpoint of prediction of operational performance. Significant differences in performance were found to exist not only for horizontal and longitudinal displacement of groups of seats, but also for individual seats. Seat location effects did not significantly attenuate the low to moderate predictive efficiency of these tests.

The question of whether loudspeaker administration of radio code tests should be replaced by other methods remains to be answered. Since acoustical properties may vary widely from room to room--especially when test rooms are nonstandard as in many Army testing situations--findings from the Creager-Detter experimentation cannot be widely generalized. That location effects do exist, however, and may vary according to specific test situations, raises the question of test reliability. Another important question is whether significant attenuation would result for tests having higher validity than the ARC-1 or SCCAT.

PREDICTING RADIO CODE OPERATOR PROFICIENCY

Kipnis and Glickman (1959) developed noncognitive measures in an attempt to predict proficiency of radio code operators. Their main hypothesis was that supervisor ratings of job performance depend more on the general behavior of subordinates than on actual performance, inasmuch as selection and training have operated to reduce individual differences in technical proficiency.

Coefficients of correlation with the three criteria were low to moderate. Current predictors did not yield statistically significant prediction of the job evaluation criterion, but an insolence key of a "risk" scale (attitudes toward authority) and a skills test (self-generated motivation) did significantly predict this criterion (-.30 and .32 respectively). The multiple correlation of these two tests with supervisor evaluations was .41.

Predictive efficiency of the noncognitive tests was usually lower than that of the cognitive predictors. However, the noncognitive measures did significantly predict supervisor ratings, which included factors other than performance of specific job duties--job willingness, respect for authority, sociability, and supervisor acceptance. Findings suggest that noncognitive predictors could add to the validity of such measures as ARC-1.

Feishman (1955) evaluated a number of auditory perception tests as predictors of proficiency in code reception. A battery of experimental tests was administered to 400 entering Air Force radio operators. In this study, loudspeaker presentation was circumvented by use of individual earphones to provide sound from test tapes. The best single predictor of the

criterion (word groups per minute received successfully at the end of 14 weeks training) was the Army Radio Code Aptitude Test ($r = .44$). Three other tests approached the magnitude of the validity obtained for the ARC-1. An r of .39 was obtained for the Code Distraction Test (detection of the number of dots in signal groups presented in rapid succession with the presence of irrelevant background noise). Rhythm Discrimination, adapted from the rhythm subtest of the Seashore Measures of Musical Talent, correlated .34 with the criterion. Dot Perception (similar to Code Distraction, but without background noise) correlated .31 with the criterion. One advantage of such tests over ARC would be elimination of the time-consuming pre-trial learning phase.

FACTORS ASSOCIATED WITH CODE RECEIVING PROFICIENCY

Highland and Fleishman (1958) organized code errors into meaningful categories derived empirically from code error data in an attempt to classify the most frequently made errors in code reception. The data collected were "substitution" errors (responses to auditory numbers or letters which were different from the ones actually sent). Data were collected in error pairs which consisted of the signal sent and the erroneous response to the signal. From responses of 299 Air Force students beginning radio code training, 34 most frequent error pairs were tabulated in order of difficulty. The 299 "scores" for each of the 34 error pairs were correlated with scores for each of the less frequent error pairs. The resulting correlation matrix was subjected to factor analysis.

Of seven factors identified, dot estimation and end-element substitution accounted for the largest percentage of errors. The tendency to "shorten" responses, that is, to leave out a dot or dash actually in the signal, was ordinarily greater than the tendency to "lengthen". The authors suggested that including factors of this type in code aptitude tests would result in increased validity of such tests, especially in high levels of code proficiency, where most errors are of the dot estimation and end element substitution type.

To gain more knowledge about fundamental aptitudes involved in radio code performance, Fleishman, Roberts, and Freidman (1958) conducted a study whereby 14 experimental aural and written predictors were factored using the criterion of days taken to attain a code-receiving speed of 14 groups per minute. Tests were administered to 310 airmen prior to their entrance into radio operator training.

Three of the six ability factors extracted--speed of closure, auditory rhythm perception, and auditory perceptual speed--were thought to be important contributors to individual differences in proficiency of Morse code reception. A dot perception test (Fleishman, 1955) and the Army Radio Code Aptitude Test were included as variables in the rhythm perception and auditory perceptual speed factors. The Copying Behind Test, in which the

examinee had to mark down series of numbers presented aurally in rapid succession, loaded on all three factors. From the study as a whole, a "closure" factor has been postulated in code proficiency. In addition, aural tests gave better prediction of the criterion than did the written ones.

Fleishman and Fruchter (1960) were interested in determining the predictability of successive stages of learning Morse code using the factor structure obtained in the study in which the "closure" factor was demonstrated (Fleishman, Roberts and Friedman, 1958). Records were obtained of the number of days required by the 310 radio operator students to reach four successive proficiency levels--4 word groups per minute, to go from 4 to 6, from 6 to 10, and from 10 to 14. Correlation coefficients were then computed between the ability tests and days taken to reach each stage.

Auditory rhythm discrimination and auditory perceptual speed appeared to indicate individual differences in speed of learning during the early phases of training, but played a smaller role, along with speed of closure, in the intermediate stages of learning. Individual differences reflected by these common abilities appeared to be less critical in the later stages of learning, overall predictability of proficiency in code learning decreasing as learning increases. It was suggested by the authors that progress in the later phases of training is more a function of specific habits acquired during training.

Goffard (1960) attempted to determine if increased interest and motivation would accelerate the rate of code learning. Subjects were students in the High Speed Radio Operation (MOS 052) course and the Radio Teletype Operation (MOS 053) course. The main approach was to modify standard training programs by inserting meaningful material in messages received (increased variety) and by progressively increasing the speed of messages received during a given practice session (increased challenge). Although students reported that the experimental programs were more interesting than the standard program, neither of the two variations introduced experimentally proved to be significantly more effective than the standard program.

APPLICABILITY OF FINDINGS TO FUTURE RESEARCH

Research studies conducted during the past few years in the selection and classification of radio code personnel have concentrated on the identification of factors fundamental to aptitudes and proficiency levels, the reliability of aural code tests, and the development of new predictors. Approaches suggested by reported research findings and methods of investigation are summarized below.

TEST RELIABILITY

Aural code tests could be studied under varying environments typical of Army testing set-ups. If reliability proves to be low under these conditions, other methods of administering aural code tests should be investigated. Methods should be sought to reduce variance associated with loud-speaker administration, including presentation by individual earphones.

STUDY OF ARC-1 TEST CONTENT

ARC-1 test records provide readily available material for the study of item response groups (errors). Differences in response patterns of successful and unsuccessful trainees could be investigated. If differences are significant, alternate scoring procedures could be devised as a means of concentrating more heavily on the more discriminating groups of item patterns; or test content could be revised to emphasize the more discriminating item groups.

FACTORS RELATED TO SCHOOL SUCCESS

An attempt could be made to identify factors essential to success in radio code school through interviews with subject matter experts and observation of "good" and "poor" students. Interviews would be expected to provide information on

1. Acquired habits and behaviors inculcated by instructors and considered essential to achievement
2. Important conative-emotional aspects of code learning (problem-solving behavior, motivation, attitudes)
3. Cognitive attributes (intellectual abilities and critical physical capacities such as dexterity and hearing).

Direct observation of students demonstrating various levels of proficiency could be made at this juncture. Various phases in the learning processes of fast learners and slow learners would be observed to note what, if any, differences in response patterns characterized the two groups. Clues would be sought in specific factors which appear to differentiate the successful student from the unsuccessful. Work habits and problem solving behavior would be investigated from the standpoint of difference between the successful and the unsuccessful.

From this investigation insight may also be gained into learning ability and habits acquired during training and the interplay of the two factors as determinates of school success. One approach would be to determine the predictive efficiency of available radio code measures at various phases of training.

EXPERIMENTAL MEASURES

New measures might be designed to enhance prediction of success in radio code MOS. Some of the factors emphasized in prior research, such as speed of closure, auditory perception of rhythm, and perceptual speed, could be investigated more thoroughly. Basic to this approach is a better understanding of these factors and of the kinds of test likely to be good measures of a given factor. Research aimed at predictor development would include investigation of psychophysical phenomena, auditory grouping ability required for good closure in a confused field, sensory threshold requirements, and j.n.d.'s.

SUMMARY

Decreased demand in the recent past for Army enlisted personnel having training in Morse code has held up decision to reevaluate the operational Army Radio Code Test which was part of the original Army Classification Battery introduced in 1949.

A recent survey was made by the New Classification Techniques Task personnel to help determine if the ARC-1 is still needed as a classification device in light of current and future demands for radio code operators. Results of the survey suggest that demands for these operators are on the increase at present.

Literature pertaining to research in the radio code area was reviewed. Recent research in this area has been oriented toward specifying fundamental abilities underlying radio code proficiency, as well as toward the development of new predictors. Based on the survey and on the review, suggestions are made for exploratory investigations which may prove to be of value in formulating research plans to enhance predictive efficiency of radio code tests. These suggestions include checking the reliability of aural code tests under typical Army testing conditions, examining ARC-1 test content for unique groups of item response patterns which would differentiate successful from unsuccessful trainees, conducting studies at radio code training centers in an attempt to find factors in the training process critical to radio code performance, and designing experimental measures to supplement the ARC-1.

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Creager, J. A., and Detter, H. M. The relation between seat location and performance on two Radio Code tests using loudspeaker administration. AF Personnel and Training Research Center, Lackland AFB, Texas. Technical Report AFPTAC-54-64, 1954.

Fleishman, E. A. Predicting code proficiency of radiotelegraphers. J. Appl. Psych., 1955, 39, 150-155.

Fleishman, E. A., and Fruchter, Benjamin. Factor structure and predictability of successive stages of learning Morse code. J. Appl. Psych., 1960, 44, 97-101.

Fleishman, E. A., Roberts, M. M., and Friedman, M. P. A factor analysis of aptitude and proficiency measures in radiotelegraphy. J. Appl. Psych., 1958, 42, 129-135.

Goffard, S. J. Experimental studies of skill in copying international Morse code. Human Resources Research Office Technical Report 68. December 1960.

Helme, William H. Differential validity of the ACB for courses in seven job areas. U. S. Army Personnel Research Office. Technical Research Report 1118. April 1960.

Highland, R. W., and Fleishman, E. A. An empirical classification of error patterns in receiving Morse code. J. Appl. Psych., 1958, 42, 112-119.

Kipnis, David, and Glickman, Albert S. The development of a noncognitive battery: Prediction of radioman performance. Bureau of Naval Personnel. Technical Bulletin 59-14. June 1959.

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Creager, J. A., and Detter, H. M. The relation between seat location and performance on two Radio code tests using loudspeaker administration. AF Personnel and Training Research Center, Lackland AFB, Texas. Technical Report AFPTRC-54-64, 1954.

Purpose. To determine if seat location effects exist under a specified set of testing conditions. If such effects do exist, are they serious from the standpoint of prediction of operational performance?

Method. The Signal Corps Aptitude test (SCCAT) and the Army Radio Code Aptitude Test (ARC-1) were administered experimentally to 2507 basic airmen at Lackland AFB. The testing room comprised one-half of a single story building of the military barracks type. Tests were administered using magnetic tapes and equipment commonly available for auditorium public address systems. Two speakers were used on the left wall of the testing room--one located 9 feet from the front of the room, the other 18 feet from the back. Both were mounted 8 feet from the floor.

In order to answer the question regarding the existence of seat location effects under the above testing conditions, the data from each code test administration were analyzed using two different designs. Design A analyzed the variance of each seat without grouping. Design B analyzed the variance of mean scores for seats grouped in terms of horizontal and longitudinal displacement in the testing room. Of the 107 seats in the room, means and standard deviations were computed for 90 seats. From 20 to 30 examinees were tested for each of these 90 seats.

Results. Statistically significant seat location effects were demonstrated for both the SCCAT and ARC tests under both designs. The question of whether such seat location effects were of practical significance, in the sense of attenuating the predictive efficiency of the aural code tests, was also investigated. Practically no attenuation of validity for either the ARC or SCCAT was noted.

Fleishman, E. A. Predicting code proficiency of radiotelegraphers. Journal of Applied Psychology, 1955, 39, 150-155.

Purpose. To evaluate a number of auditory perceptual tests as predictors of proficiency in telegraphic code reception.

Method. A battery of experimental tests were administered to 400 entering radio operators at Keesler AFB. Sound from testing tapes was presented to each examinee through individual earphones in administering the following experimental measures:

1. Pitch discrimination
2. Loudness discrimination
3. Rhythm discrimination
4. Time discrimination
5. Timbre discrimination
6. Tonal memory
7. Dot Perception Test. A series of 55 signal groups consisting of rapid patterns of "dots" and "dashes". For each series, the examinee had to indicate the number of dots presented.
8. Code Distraction Test. 150 signal groups similar to those presented in the Dot Perception Test. The signal groups were administered in the presence of irrelevant background auditory signals. The examinee had to indicate the number of dots presented in each series.
9. Army Radio Code Aptitude Test

The criterion measure was the number of groups per minute received successfully at the end of 14 weeks training. Means, standard deviations, intercorrelations and validity coefficients were computed for all variables. Corrections for double restriction (due to selection on the basis of the ROAI and SCCAT tests), using the matrix multivariate restriction formulas described by Thorndike, were applied for all intercorrelations and validity coefficients. A test selection was computed for the individual tests

Results. The best single predictor was the Army Radio Code Aptitude test ($r = .44$). Three other tests approached the magnitude of the validity obtained for the ARC: Code Distraction ($r = .38$), Dot Perception ($r = .31$) and Rhythm Discrimination ($r = .34$). A combination of the ARC, Rhythm discrimination, and Code Distraction tests yielded a multiple coefficient of correlation with the criterion of .51.

Fleishman, E. A., and Fruchter, Benjamin. Factor structure and Predictability of successive stages of learning Morse code. *Journal of Applied Psychology*, 1950, 44, 97-101.

Purpose. To determine the predictability of successive stages of learning Morse code.

Method. A battery of 14 ability tests was administered to 310 entering radio operator students. Records were obtained of the number of days required by these students to reach four successive proficiency levels of Morse code reception. These levels were the number of days to obtain a speed of 4, 4 to 6, 6 to 10 and 10 to 14 groups per minute. Correlations were then computed between the ability tests and student progress during the 4 stages of training. A factor analysis of the ability measures was carried out and the factor structure of the criterion measures determined^{1/}:

Results. Results suggest that two auditory abilities--Auditory Rhythm Discrimination and Auditory Perceptual Speed--indicate individual differences in speed of learning Morse code during the early phases of training. In the intermediate stages of learning these abilities play a smaller role along with speed of closure. In the late phases of training individual differences in these common abilities are less critical--overall predictability of proficiency in code learning decreases as learning increases. Tests in this area are valid mainly for predicting success only for the early phases of training. At later phases, progress is more a function of specific habits acquired in training.

^{1/}For a detailed description of the 14 predictor tests and factor structures see Fleishman, E. A., Roberts, M. M., and Friedman, M. P. A Factor Analysis of Aptitude and Proficiency Measures in Radio-telegraphy. *Journal of Applied Psychology*, 1958, 42, 129-135.

Fleishman, Edwin A., Roberts, Millard M., and Friedman, Morton P. A factor analysis of aptitude and proficiency measures in radiotelegraphy. Journal of Applied Psychology, 1958, 42, 129-135.

Purpose. The purpose of this study was to obtain more knowledge about the fundamental aptitudes involved in radiotelegraphy through the application of factor analysis techniques to both aptitude measures and proficiency criteria. Despite the variety of studies on Morse code, little is known about fundamental abilities underlying proficiency in this skill.

Method. Fourteen tests were administered to 310 applicants prior to their entrance into radio operator training. Five of these tests were auditory, nine were printed. All were hypothesized to measure abilities relevant to success in learning morse code.

Experimental variables were:

1. Rhythm Discrimination. An adaptation of the rhythm subtest of the Seashore Measures of Musical Talent. The task was to indicate for each pair of rhythm patterns whether they were the same or different. 70 pairs were presented in all.

2. Dot Perception. A series of dots and dashes were presented in rapid succession. For each presentation the examinee had to indicate the number of dots heard. The speed of transmission increased in succession throughout the test of 160 items.

3. Copying Behind. Groups of numbers were called out in rapid succession. The task was to mark down the numbers for each series. The speed of transmission increased from the start to the finish of the test (240 items).

4. Hidden Tunes. A series of short tunes were administered in pairs. The last tune was always longer than the first. The task was to indicate whether the first tune was included as part of the second one (50 pairs).

5. Army Radio Code. The APC test included as part of the Army Classification Battery.

6. Four-letter Words. Twenty-two 46-letter lines were printed on a page in capital letters. The examinee had to circle all of the 4-letter words which could be found in sequence in this array.

7. Gestalt Completion. Drawings representing only suggestive parts of objects were portrayed. The task was to identify the objects.

8. Mutilated Words. Word completion of words with parts of each letter missing.

9. Designs. The task was to identify the symbol for sigma which was embedded in 40 of 300 geometrical designs presented.

10. Concealed Figures. The examinee was required to select one of five given geometrical figures that was contained in a more complex geometrical field.

11. Marking Accuracy. The task was to mark on an IBM answer sheet, which one of 5 alternatives to each item had been overprinted with a small circle. This speeded test was taken to be the visual counterpart of the Copying Behind test.

12. Word Knowledge. A multiple-choice vocabulary test.

13. Background for Current Affairs. A test of current history and events.

14. Pattern Comprehension. A series of drawings in which the examinee had to visualize the relationships between components of solids and their unfolded, flat projections.

The criterion used was the number of days taken for each examinee to attain a code receiving speed of 14 groups per minute. Intercorrelations among 14 variables and the criterion were obtained. Correction for restriction in range (selection for training on the basis of the Airman Classification Battery) was made. A factor analysis was performed using Thurstone's centroid method. Orthogonal rotations, using Zimmerman's graphical procedure, were continued until simple structure appeared to be closely approximated.

Results. Six factors were extracted. These factors were interpreted as (1) visualization, (2) verbal ability, (3) auditory rhythm perception, (4) speed of closure, (5) auditory perceptual speed, and (6) residual. Results suggest that 3 of the ability factors contribute to individual differences in proficiency of Morse code reception: speed of closure, auditory rhythm perception, and auditory perceptual speed. Both the Dot Perception and Army Radio Code Aptitude tests were included as variables

in the rhythm perception and perceptual speed factors. The Copying Behind test appeared in all 3 of the factors.

A major contribution of this study was stated as being the demonstration of a "closure" factor in code proficiency. Also, results of earlier studies were confirmed in that aural tests gave better prediction of code proficiency than most printed tests. A multiple R of .66 was stated as being probable using these variables as predictors of the criterion. A multiple correlation study using a wider range of predictors is presently being conducted.

Goffard, S. J. Experimental studies of skill in copying international Morse code. Human Resources Research Office Technical Report 68. December 1960.

Purpose. The main purpose of this research effort was to determine if increased interest and motivation would accelerate the rate of code learning. Proficiency in code skills is known to increase at a relatively slow rate. Practice sessions, in which students spend from one-third to one-half their total course time, are often tedious and monotonous. The tedious phase comes after basic code (36 code characters) has been learned.

Method. An attempt was made to raise the level of interest and motivation among students in the High Speed Radio Operator (MOS 052) course and the Radio Teletype Operation (MOS 053) course. Two experimental modifications were made within the code practice portion of each course. In the first experimental program code messages were embedded in context as a means of arousing the interest of the students. In addition, each message was sent twice in succession, the first time to be copied and the second time to enable students to check the accuracy of their copy immediately. The second experimental program was a progressive practice type in which the material to be copied was sent at several different code speeds rather than at only one speed as in conventional practice. The messages to be copied were in ascending order of speed, thus providing a progressively sharper challenge to the student. Again, each message was sent twice in succession. The rate of skill acquisition of students in the two experimental programs was compared with that of students in the standard program.

Experimenters considered that the conventional "speed check" was a measure, not of actual skill at code copying, but rather of whether or not a man had reached a specified level of skill. The criterion measure adopted for the study consisted of a series of brief tests given at several different speeds during various phases of training. The measure was designed to indicate at exactly what speed a man could be expected to copy code with 90 percent accuracy.

Results. Although students reported that the experimental programs were more interesting than the standard program, neither modified program proved to be significantly more effective than the standard program.

Helme, William H. Differential validity of the ACB for courses in seven job areas. U. S. Army Personnel Research Office. Technical Research Report No. 1118. April 1960.

A comprehensive study of the effectiveness of ACB tests for differential classification was made utilizing results obtained in 73 different Army school courses. Four tests--Army Clerical Speed, Automotive Information, Electronic Information, and Army Radio Code Aptitude--were found to be effective differential selectors for related job areas. Results obtained on the ARC-1, as a differential selector, indicated the need for new alternate forms, but construction of these forms has been held in abeyance in view of a decreasing demand in the number of personnel required for radio-code jobs from 1953 to 1961.

Highland, Richard W. and Fleishman, Edwin A. An empirical classification of error patterns in receiving Morse code. *Journal of Applied Psychology*, 1958, 42, 112-119.

Purpose. To organize code errors into meaningful categories derived empirically from code error data. Specifically, to (1) determine the order of difficulty of the most frequent substitution errors, (2) apply factor analysis to the intercorrelations among the errors, and (3) examine the relationship between the error factors obtained and the most frequently made errors.

Method. The data collected were "substitution" errors--responses to auditory numbers or letters which were different from the actual ones sent. Data were collected in error pairs which consisted of the signal sent and erroneous response to the signal. In all, 1260 possible errors could be made from the 26 alphabetical letters and numbers (0-9) that were sent. Out of responses from 299 students a table was computed to show the 34 most frequent error pairs in order of difficulty. The 299 "scores" for each of the 34 error pairs were correlated with scores for each of the other pairs. The resulting correlation matrix was factored using the Thurstone centroid method.

Results. Seven factors were identified: Dash estimation, dot estimation, end-element substitution, internal error, doublet, and residual (factors 6 and 7). Dot estimation and end-element substitution accounted for the largest percentage of errors, and the response tendency for "shortening" was ordinarily greater than the response tendency for "lengthening". The authors suggest that including these factors in code aptitude tests would result in increased validity of such tests. Another hypothesis was that items emphasizing dot estimation and end-element substitution in code aptitude tests might prove to be beneficial in predicting high levels of code proficiency, since most of the errors are of this type. In other terms, such measures may be more predictive of final asymptotes in code learning than present measures.

Kipnis, David and Glickman, Albert S. The Development of a noncognitive battery: Prediction of radioman performance. Bureau of Naval Personnel. Technical Bulletin 59-14. June 1959.

Purpose. To develop noncognitive tests to predict performance evaluations of enlisted personnel in radiotelegraphy.

Method. Since grades at training schools have shown only meager relationships with duty performance evaluations, it was assumed that judgments of performance effectiveness are strongly influenced by the extent to which subordinates' behaviors show acceptance of the supervisor's influence and promote confidence in the subordinate's ability to do the work. Differences in technical proficiency apparent to supervisors on the job are decreased by selection and training in the school; thus, supervisors may have to compare their men on the basis of other factors. To test this hypothesis, criteria included on-the-job performance ratings, as well as final school grades and a test of code proficiency. The sample consisted of 141 recruits entering Class A, RM School, U. S. Naval Training Center, Bainbridge, Maryland.

Predictors:

Experimental Tests

1. Hand Skills Test. A test of the speed of use of hands and fingers. It was assumed that this test taps a characteristic likely to be valued by supervisors, i.e., self-generated motivation persisting beyond minimal levels of achievement.
2. Error Finding Test. A measure of ability to work fast without making mistakes. The hypothesis underlying this test was that those who lack confidence in their own perceptions or judgments will not receive the confidence of their supervisors.
3. Color Naming Test. A test of reaction time to unexpected stimuli. The hypothesis underlying the test was that disorganization or sluggishness in dealing with stressful situations may be a basis of low performance evaluations.
4. Risk Scale. A test of risk-taking behavior. It was inferred that men who score high on this scale display a hostile and insolent attitude toward authority.
5. Sports Information. A multiple-choice test on the rules and play of various sports.

Currently Operational Predictors

6. General Classification Test
7. Arithmetic
8. Mechanical Test
9. Clerical Test
10. Radio Code Aptitude Test

Criteria:

1. Radio man School Performance. Final grade ranging from 55% to 100%.
2. Grade on Code Copying Test (CODE / FOX) at the end of 12 weeks of training. Scores ranged from 7 to 48 words per minute.
3. On-the-job Performance 13 months after testing. A total performance score derived from five 14-point scales covering job willingness, technical competence, respect for authority, peer sociability, and supervisor acceptance.

Means, standard deviations, and intercorrelations were obtained for and among all selectors. Triserial product moment correlation coefficients were computed between predictors and the three criteria. Finally, coefficients of multiple correlation were obtained for the total test battery for each criterion.

Results. The Sports Scale and the Risk Scale significantly predicted final RM grades, with r 's of .19 and -.31, respectively. The addition of these two tests to the best combination of current selection tests (RCAT / ARI / GCT) raised the multiple correlation with final grade from .34 to .46. The Hand Skills Test (.19), Color Naming Test (.25), and the Risk Scale (-.21) gave significant prediction of CODE / FOX scores. These tests raised the multiple of the best current predictors from .35 to .46.

Analysis of current measures did not result in statistically significant prediction of the job evaluation criterion. An insolence key of the Risk Scale and the Hand Skills Test did significantly predict this criterion (-.30 and .12, respectively). The multiple correlation of these two tests with supervisor evaluations was .41.